materials proceedings

MDPI

Abstract

Development of Magnetic Nanofibrous Membranes for Localized Solid Cancer Treatment †

Adriana Gonçalves, Joana Matos, Raquel Cabrita, Inês Rodrigues, João Paulo Borges and Paula I. P. Soares *

Department of Materials Science, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516 Caparica, Portugal; aml.goncalves@campus.fct.unl.pt (A.G.); jfa.matos@campus.fct.unl.pt (J.M.); r.cabrita@campus.fct.unl.pt (R.C.); ics.rodrigues@campus.fct.unl.pt (I.R.); jpb@fct.unl.pt (J.P.B.)

* Correspondence: pi.soares@fct.unl.pt

† Presented at the Materiais 2022, Marinha Grande, Portugal, 10–13 April 2022.

Keywords: thermosensitive polymers; dual-stimuli device; magnetic hyperthermia

The present work focuses on the development of dual-stimuli electrospun fibers embedded with thermoresponsive PNIPAAm microgels and iron oxide magnetic nanoparticles for a synergic effect between magnetic hyperthermia and controlled drug release as an alternative localized cancer treatment for solid tumors. Superparamagnetic iron oxide nanoparticles were successfully synthesized using a chemical co-precipitation technique and stabilized with oleic acid (OA) and dimercaptosuccinic acid (DMSA). Thermoresponsive PNIPAAm microgels with a lower critical solution temperature of 32 °C were synthesized through surfactant-free emulsion polymerization [1–3]. Poly(vinyl alcohol) (PVA) was used as a fiber template, and a fiber diameter of about 180 nm was obtained. PNIPAAm microgels and mNPs were incorporated into the nanofibers through colloidal electrospinning, and dual-stimuli nanofibrous membranes were produced. To avoid their dissolution in an aqueous medium, the membranes were submitted to physical crosslinking. Stress tests confirm that the crosslinking of the membranes increases their mechanical parameters and that the presence of microgels and nanoparticles acts as a reinforcement in the fibers. The swelling ability of the membranes is shown to decrease in the composite membranes when compared with plain PVA membranes due to the presence of magnetic nanoparticles. Magnetic hyperthermia assays show promising results regarding the heating ability of the magnetic membranes incorporated into the fibers. PVA fibers incorporated with DMSA-coated nanoparticles were capable of reaching therapeutic temperatures for hyperthermia treatment, indicating that the device is a viable option in cancer treatment. In drug-release assays, PVA fibers with a model drug, doxorubicin (DOX), were produced, and controlled release was studied in different pH solutions (4.5, 6.5, and 7.4) at 37 °C. Assays showed a more significant release of DOX at pH = 7.4. Finally, to evaluate the cytotoxic effect of the device, cytotoxicity assays of PNIPAAm microgels and PVA fibers were performed in Vero and SaOs-2 cells. All assays reveal the absence of cytotoxicity, indicating the possibility of using the device in biomedical applications. A dual-stimuli electrospun device was successfully developed, and the present work demonstrates its potential for magnetic hyperthermia and controlled drug release that shows potential as an alternative cancer treatment.

Author Contributions: Conceptualization, A.G. and P.I.P.S.; methodology, A.G., J.M., R.C., I.R.; validation, A.G. and P.I.P.S.; writ-ing—original draft preparation, A.G.; writing—review and editing, all authors; supervision, P.I.P.S. and J.P.B.; funding acquisition, P.I.P.S. and J.P.B. All authors have read and agreed to the published version of the manuscript.

Funding: This work is co-financed by FEDER, European funds, through the COMPETE 2020 POCI and PORL; National Funds, through the FCT—Portuguese Foundation for Science and Technology

Citation: Gonçalves, A.; Matos, J.; Cabrita, R.; Rodrigues, I.; Borges, J.P.; Soares, P.I.P. Development of Magnetic Nanofibrous Membranes for Localized Solid Cancer Treatment. *Mater. Proc.* **2022**, *8*, 119. https://doi.org/10.3390/materproc2022008119

Academic Editors: Geoffrey Mitchell, Nuno Alves, Carla Moura and Joana Coutinho

Published: 11 July 2022

and POR Lisboa2020, under the project POCI-01-0145-FEDER-007688, reference UIDB/50025/2020-2023, and project DREaMM, reference PTDC/CTM-CTM/30623/2017. A.G. acknowledges the FCT for the Ph.D. grant with reference 2021.06558.BD. P.S. also acknowledges the individual contract CEECIND.03189.2020.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Gonçalves, A.; Almeida, F.V.; Borges, J.P.; Soares, P.I. Incorporation of Dual-Stimuli Responsive Microgels in Nanofibrous Membranes for Cancer Treatment by Magnetic Hyperthermia. *Gels* **2021**, *7*, 28. [CrossRef] [PubMed]
2. Matos, R.J.; Chaparro, C.I.; Silva, J.C.; Valente, M.A.; Borges, J.P.; Soares, P.I. Electrospun composite cellulose acetate/iron oxide nanoparticles non-woven membranes for magnetic hyperthermia applications. *Carbohydr. Polym.* **2018**, *198*, 9–16. [CrossRef]
3. Soares, P.I.; Romao, J.; Matos, R.; Silva, J.C.; Borges, J.P. Design and engineering of magneto-responsive devices for cancer theranostics: Nano to macro perspective. *Prog. Mater. Sci.* **2021**, *116*, 100742. [CrossRef]